

Is charm the key to understanding diffraction in DIS ?

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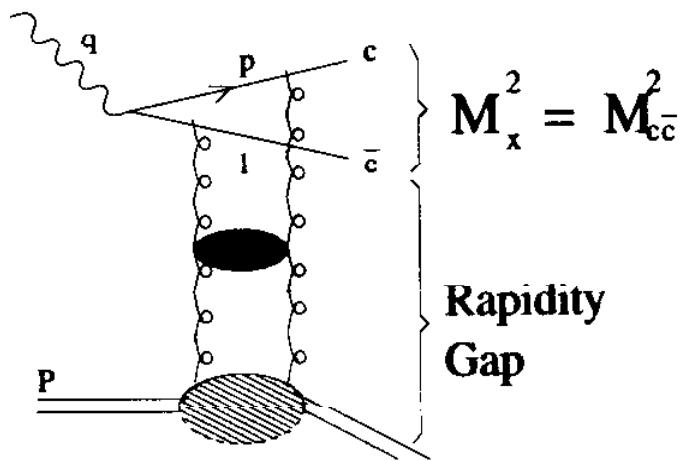
- High energy, small x , *diffractive*, hadron scattering
→ Large rapidity gaps
- Diffractive events at small x in DIS surprising from p.o.v. of QCD
- Models of diffraction in DIS
 1. two gluon exchange in t-channel
 2. semiclassical approach in PRF
- large charm mass → QCD calculable cross section
- First Data : H1 collab., pa02-060, ICHEP, Warsaw, 1996
- Compare predictions of two models:
→ propose two phenomenological tests

ZEUS here

Two gluon exchange models

Landshoff, Nechtmann; Low, Nuovo; Nikolaev, Zakharov; Bartels, Ewerz, Levin, Lotter, Wiethoff; etc....

Charm -> Levin, Martin, Ryskin and Teubner, hep-ph/9606443 ; Genovese, Nikolaev and Zakharov, Phys. Lett. B378 (1996) 347; Lotter - hep-ph/9612415; Diehl - hep-ph/9701252.



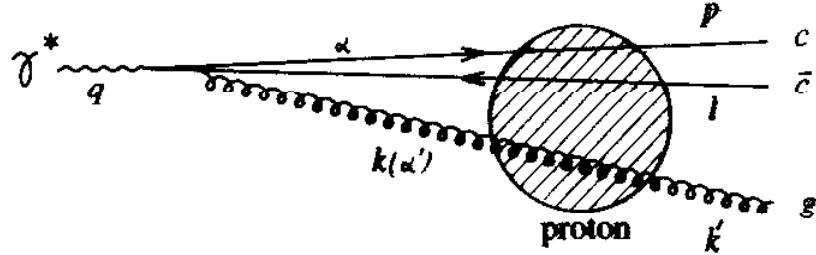
- simplest QCD model
→ two gluons, in singlet config. exchanged in t-channel
- interacting gluons ?
- additional gluon important at low $\beta = Q^2/(Q^2 + M_x^2)$
but full calculation of $\mathcal{O}(\alpha_s)$ not available
estimates (LMRT) → ignore at intermediate β

Simplified differential cross sections (in DLLA)

$$\begin{aligned}\frac{d^2\sigma_L}{d\alpha dp_\perp^2} &= \frac{2e_c^2 \alpha_{em} \alpha_s^2 \pi^2 [\xi G(\xi)]^2 C}{3(a^2 + p_\perp^2)^6} [\alpha(1-\alpha)]^2 Q^2 (a^2 - p_\perp^2)^2 \\ \frac{d^2\sigma_T}{d\alpha dp_\perp^2} &= \frac{e_c^2 \alpha_{em} \alpha_s^2 \pi^2 [\xi G(\xi)]^2 C}{6(a^2 + p_\perp^2)^6} [1(\alpha^2 + (1-\alpha)^2)p_\perp^2 a^4 + m^2(a^2 - p_\perp^2)^2] \\ a^2 &= \alpha(1-\alpha)Q^2 + m_s^2\end{aligned}$$

Semi-classical approach

Buchmüller, Hebecker, McDermott - hep-ph/9703314; Nucl. Phys. B487 (1997) 283;
 Buchmüller, Hebecker B476 (1996) 203.



- Proton rest frame calculation.
- Slow gluon for diffraction, $\alpha' = k_0/q_0 \ll 1$, photon fluct. develops large transverse size : aligned jet type config.

$$\begin{aligned} \frac{d\sigma_L}{d\alpha dp_\perp^2 d\alpha' dk'^2} &= \frac{e_s^2 \alpha_{em} \alpha_s}{16\pi^2} \frac{\alpha' Q^2 p_\perp^2}{[\alpha(1-\alpha)]^2 N^4} f(\alpha' N^2, k'_\perp) \\ \frac{d\sigma_T}{d\alpha dp_\perp^2 d\alpha' dk'^2} &= \frac{e_s^2 \alpha_{em} \alpha_s}{128\pi^2} \frac{\alpha' \{ [\alpha^2 + (1-\alpha)^2] [p_\perp^4 + a^4] + 2p_\perp^2 m_c^2 \}}{[\alpha(1-\alpha)]^4 N^4} f(\alpha' N^2, k'_\perp) \\ f(\alpha' N^2, k'_\perp) &= \int_{x_\perp} \left| \int \frac{d^2 k_\perp}{(2\pi)^2} \left(\delta^{ij} + \frac{2k_\perp^i k_\perp^j}{\alpha' N^2} \right) \frac{\text{tr} \tilde{W}_{x_\perp}^A (k'_\perp - k_\perp) \right|^2 \\ N^2 &= Q^2 + \frac{p_\perp^2 + m_c^2}{\alpha(1-\alpha)} \end{aligned}$$

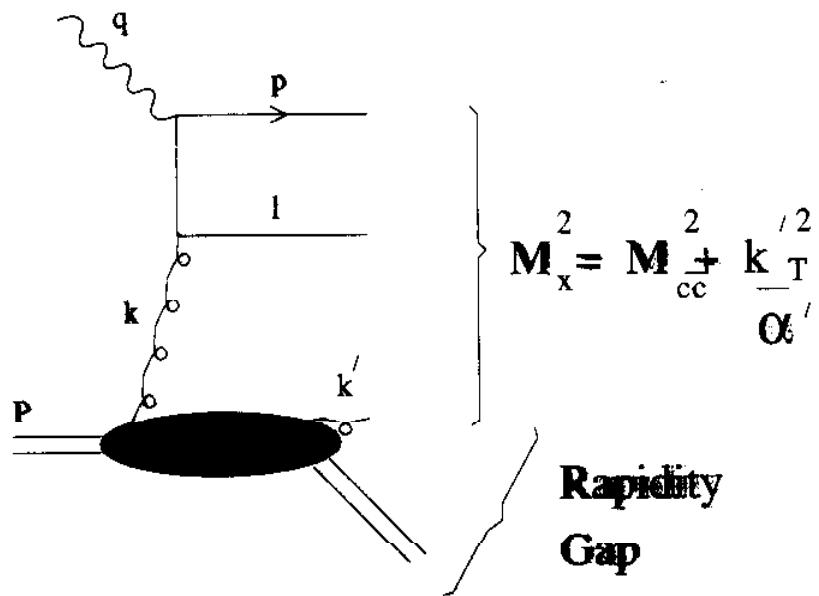
- Other graphs suppressed by Λ^2/m_c^2 (propagator factor)
- Integration over f.s. gluon variables, α', k'^2 in LL($1/x$) approx gives

$$\begin{aligned} \frac{d\sigma_L}{d\alpha dp_\perp^2} &= \frac{e_s^2 \alpha_{em} \alpha_s \ln(1/x) h_A}{2\pi^3 (a^2 + p_\perp^2)^4} [\alpha(1-\alpha)]^2 Q^2 p_\perp^2 \\ \frac{d\sigma_T}{d\alpha dp_\perp^2} &= \frac{e_s^2 \alpha_{em} \alpha_s \ln(1/x) h_A}{16\pi^3 (a^2 + p_\perp^2)^4} [(\alpha^2 + (1-\alpha)^2) (p_\perp^4 + a^4) + 2p_\perp^2 m_c^2] \\ h_A &= \int_{y_\perp} \int_{x_\perp} \frac{|\text{tr} \tilde{W}_{x_\perp}^A (y_\perp)|^2}{y_\perp^4} \end{aligned}$$

- p_\perp^2 logarithmically distributed between m_c^2 and Q^2 in 2 gluon exchange models typical $p_\perp^2 \sim m_c^2$

- Boost to Breit frame
- initial state slow gluon turns around
reinterpret as *incoming* gluon, momentum fraction y
- Kinematically like boson-gluon fusion
off diffractive gluon density in proton,
with additional final state gluon
- see A. Hebecker hep-ph/9702373

$$\frac{d\sigma}{d\xi} = \int_x^\xi dy \hat{\sigma}(y) \left(\frac{df(y, \xi)}{d\xi} \right)$$



Phenomenological Tests

1. How many events have $p_{\perp}^2 > p_{\perp,\min}^2$?

$$\sigma(p_{\perp,\min}^2) = \int_{p_{\perp,\min}^2}^{\infty} dp_{\perp}^2 \int_0^1 d\alpha \frac{d^2\sigma}{dp_{\perp}^2 d\alpha}$$

2. Mass spectrum : compare M_x^2 and M_{cc}^2
3. Energy Dependence

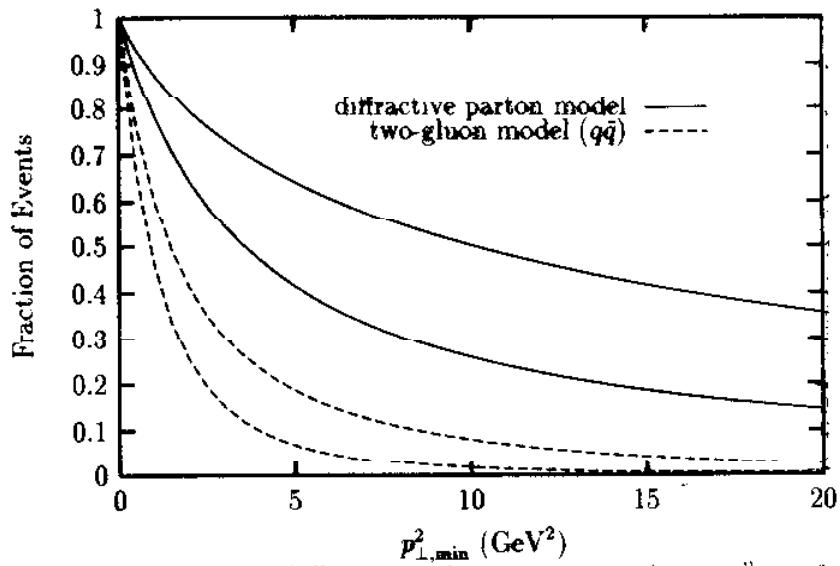


Figure 1. The fraction of diffractive charm events above $p_{\perp,\min}^2$ for Q^2 of 10 GeV^2 and 100 GeV^2 (lower and upper curve in each pair).

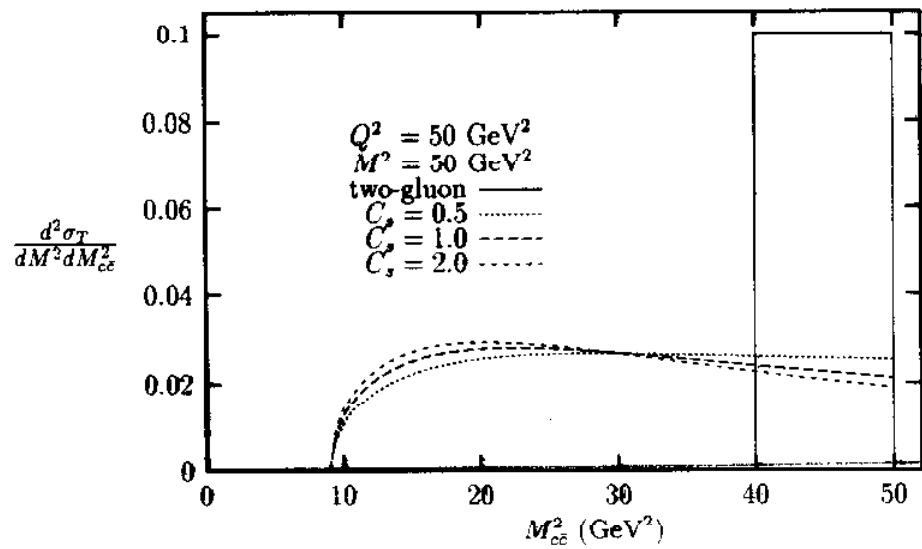


Figure 2. Normalized mass spectra for the eikonal model and the two-gluon model.